



**OHIO DEPARTMENT OF TRANSPORTATION**  
CENTRAL OFFICE, 1980 W. BROAD ST., COLUMBUS, OHIO 43216-0899

January 16, 2009

To: Users of the Bridge Design Manual

From: Tim Keller, Administrator, Office of Structural Engineering

By: Sean Meddles, Bridge Standards Engineer

Re: 2009 First Quarter Revisions

Revisions have been made to the ODOT Bridge Design Manual, July 2007. These revisions shall be implemented on all Department projects with a Stage 2 plan submission date after January 16, 2009.

This package contains the revised pages. The revised pages have been designed to replace the corresponding pages in the book and are numbered accordingly. Revisions, additions, and deletions are marked in the revised pages by the use of one vertical line in the right margin. The header of the revised pages is dated accordingly.

To keep your Manual correct and up-to-date, please replace the appropriate pages in the book with the pages in this package.

To ensure proper printing, make sure your printer is set to print in the 2-sided mode.

The July 2007 edition of the Bridge Design Manual may be downloaded at no cost using the following link:

<http://www.dot.state.oh.us/Divisions/HighwayOps/Structures/standard/Pages/default.aspx>

Attached is a brief description of each revision.

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## Summary of Revisions to the July 2007 ODOT BDM

BDM Section	Affected Pages	Revision Description
801	8-1	This revision introduces the new standard drawing NBS-1-09 and design data sheet NBSDD-1-09. The approved supplier list which was available in the now retired plan insert sheets are now included in the BDM as Figure 801-1 (for reflective walls) and Figure 801-2 (for absorptive walls).
802.1	8-1 through 8-3	This revision provides the design guidance for standard 30-inch diameter drilled shaft foundation. This guidance was previously available in the now retired plan insert sheets. Design tables for granular soil types and cohesive soil types are available as Figures 802.1.2-1 and 802.1.2-2 respectively.
802.2	8-3	This section has been revised to be consistent with the aesthetic requirements introduced in the new standard drawing NBS-1-09.
803	8-4 through 8-7	This section introduces design requirements for noise barriers in the project plan set. These requirements were compiled from various project plans that have sold in recent years. Before this release, noise barrier plan requirements are not defined in any Department publication.
804	8-8	Reference to the now retired plan insert sheets has been replaced.
805	8-8	The Department evaluation period for submissions has been increased from 20-days to 60-days.
805.2	8-9	Reference to the now retired plan insert sheets has been replaced.
Figure 801-1		This is a new figure for approved reflective wall suppliers. This information was previously available on the now retired plan insert sheets.
Figure 801-2		This is a new figure for approved absorptive wall suppliers. This information was previously available on the now retired plan insert sheets.
Figure 802.1.2-1		This is a new figure for the determination of 30-inch diameter drilled shaft lengths in granular soil. This information was previously available on the now retired plan insert sheets.
Figure 802.1.2-2		This is a new figure for the determination of 30-inch diameter drilled shaft lengths in cohesive soil. This information was previously available on the now retired plan insert sheets.

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## **SECTION 800 – NOISE BARRIERS**

### **801 INTRODUCTION**

According to Section 1400 of the ODOT Location and Design Manual, a Noise Wall Justification shall be included in the Preferred Alternative Verification Review Submission for Major Projects or in the Minor Project Preliminary Engineering Study Review Submission. When noise barriers are necessary, the Office of Environmental Services will furnish the required noise barrier height, length and location(s). The detail design for noise barriers shall be included in the Stage 2 Detailed Design Review Submission.

Design specifications for ground mounted precast concrete noise barrier walls are provided in Standard Bridge Drawing NBS-1-09. Associated designer notes are provided in Design Data Sheet NBSDD-1-09. The Department occasionally permits the use of noise barrier walls consisting of material types other than precast concrete. These wall types are pre-approved according to the requirements of the Department's Standard Procedure 27-005(SP) for new products and this Manual. Alternate noise barrier material types currently approved include: metal; fiberglass; brick or masonry; and acrylic. A complete listing of approved noise barrier suppliers for material types other than precast concrete are provided in Figures 801-1 and 801-2.

### **802 DESIGN CONSIDERATIONS**

#### **802.1 NOISE BARRIER FOUNDATIONS**

##### **802.1.1 GENERAL**

The Design Agency shall perform a subsurface investigation at all noise barrier locations. The subsurface work shall be in accordance with the most current revision of the ODOT Specifications for Geotechnical Explorations. The noise barrier borings shall be included in the plans with the soil profile/foundation investigation sheets.

The standard foundation for noise barrier walls is a 30-inch diameter drilled shaft with a maximum length of 30-ft. Consult the Office of Structural Engineering when specifying longer or larger diameter drilled shafts.

In regions of poor soils or where obstructions (e.g. underground utilities, drainage facilities, mse wall components, etc.) preclude the use of 30-inch diameter drilled shafts as the appropriate foundation type, consult the Office of Structural Engineering for the use of an alternate foundation type (e.g. larger diameter drilled shafts, spread footings, etc.). If bedrock is anticipated within the drilled shaft length required by BDM Section 802.1.2 and the bedrock has an unconfined compressive strength of 7500 psi or better, provide the required shaft length or a reduced length with a 3-ft minimum length rock socket. For weaker bedrock, provide the required shaft length or a reduced length with a 5-ft minimum length rock socket.

### 802.1.2 DRILLED SHAFT DESIGN

The following foundation design procedure applies to only 30-inch diameter drilled shafts. For shafts of other diameter or for design parameters that exceed those herein, the foundation shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications, Section 10.

- A. At each noise barrier boring location determine the SPT “N” blow counts for depths of 5, 10, 15, 20, and 25-ft. The SPT “N”-value is the total number of blows required to drive the sampler from 6” to 12” and from 12” to 18”.
- B. Correct the N-values based on the following depth correction factors:

Depth (ft.)	Correction Factor
5	1.60
10	1.20
15	1.00
20	0.96
25	0.90

- C. The final design “N”-value used to establish the required minimum shaft length should be based on either average or lowest corrected “N”-values as follows. When the corrected “N”-values are consistent with depth or when the corrected values increase with depth, the final design “N”-value shall be the average of the corrected values along the length of drilled shaft. Otherwise, the final design “N”-value shall be the lowest corrected value along the length of the drilled shaft. The following examples assumes a drilled shaft with a design length of 15-ft.

Depth (ft.)	Corrected “N”-value	
5	8	Design “N” = $(8+15+16)/3=13$
10	15	
15	16	
20	25	
25	30	

Depth (ft.)	Corrected “N”-value	
5	16	Design “N” = 8
10	8	
15	15	
20	25	
25	30	

- D. Establish the soil type as granular or cohesive at each boring. Soil should be considered granular when the plasticity index is less than 7.
- E. Select the Granular Soil Foundation Depth Table (Figure 802.1.2-1) or the Cohesive Soil Foundation Depth Table (Figure 802.1.2-2) to determine the required drilled shaft length for the assumed post spacing and wall height at each boring location. Refer to the Design Data



Sheet, NBSDD-1-09, for guidelines for establishing post spacing. Frequently varying plan specified shaft lengths throughout the project should be avoided, and the minimum increment of plan specified shaft length should be 2-ft.

## **802.2 NOISE BARRIER AESTHETICS**

The Department limits standard aesthetic treatments for noise barriers.

Aesthetic limitations include:

- A. Concrete wall panels shall use an Ashlar stone pattern form liner, or other approved formliner. The surface treatment detail shall be shown in the project plans. The Office of Environmental Services will approve formliners other than Ashlar stone pattern. Other wall panel materials (steel, fiberglass, etc.) will not require a form liner.
- B. Concrete posts shall be used except when mounted on bridges and other structures.
- C. Noise barrier panels and posts shall have a cap to create a shadow line. Caps for posts should be of the same material as the posts and shall be integral with or mechanically fastened to the top of the post. Caps for panels shall be integral with the panel.
- D. General dimensions for the cap are:
  - 1. 6 inches high
  - 2. 4 inches wider than the post and panel selected and centered so the cap horizontally extends 2 inches beyond the panel or posts vertical surfaces. (Other options may be acceptable depending on limits of manufacturing process and final visual effect.)
- E. The Department is standardizing color for panels and posts. Color choices should be selected from the Department's acceptable colors. The coating material used to produce the color is to be approved by the Office of Environmental Services. The noise barrier color(s) shall be determined by the designer in conjunction with the District Aesthetic Coordinator. The posts, caps and joints may have a color(s) different from the panels, but the color combination shall be visually appealing.

Color choices may also be limited due to noise panel material types. Agencies and/or designers specifying both color and wall panel material type should assure that the color is available.

Aesthetic treatments beyond these limitations require review and approval by the Office of Environmental Services.

The aesthetic requirements for each project shall be clearly defined in the noise barrier plan general notes. Those notes shall be detailed enough to assure detail finishes, form liners, caps, colors, coatings, application requirements, special design dimensions, etc. are not only adequately specified to assure the visual effect but to also assure quality of construction and materials.

## **803            DETAIL DESIGN SUBMISSION REQUIREMENTS**

### **803.1            NOISE BARRIER PLAN SHEET ORDER**

The noise barrier plan sheets shall be an individually numbered plan subset within the project plans. The plan sheet order should conform to the following:

- A. Noise Barrier Schematic Plan
- B. Noise Barrier Typical Sections
- C. General Notes
- D. Noise Barrier Subsummary
- E. Plan & Profile Sheets
- F. Cross Sections
- G. Noise Barrier Data Tables
- H. Miscellaneous Noise Barrier Details

Ensure that the soil profile/foundation investigation sheets are included in the project plans.

### **803.2            NOISE BARRIER PLAN REQUIREMENTS**

The noise barrier plans for Stage 2 Detailed Design Review shall include the following:

#### **A. Noise Barrier Schematic Plan**

The purpose of the schematic plan is to show the location of each noise barrier wall on the project (using a 1"=200' scale) and provide baseline geometry for the wall. The scale shall be shown in bar format. A north arrow shall be provided. All reference lines (e.g. centerlines of construction, baselines of ramps, etc.) should be shown. Provide roadway stationing tick marks at 100-ft. intervals.

Each noise barrier on the project shall be given a unique designation (e.g. Noise Barrier #1, Noise Barrier #2, etc.) and unique stationing. The noise barrier stationing shall be independent of the roadway stationing. Provide the noise barrier station; the roadway station; and the offset from the roadway reference line for the beginning and ending points for each wall on the project.

The baseline geometry for the wall may be provided in tabular format. At a minimum, the geometry shall provide the noise barrier station; the roadway station and offset; and the bearing from for all points of tangency along the barrier alignment.

#### **B. Noise Barrier Typical Sections**

1. Identify the roadway centerline and dimension the outside traffic lanes, paved shoulder

width and graded shoulder width.

2. Dimension the location and identify the type of roadside barrier protection (if required). Noise barrier located within the clear zone requires protection in the form of guardrail or concrete barrier. The clear zone shall be measured to the nearest face of the post.
3. Dimension the location of the noise barrier with respect to the roadway centerline or the face of the roadside barrier protection (if available).
4. Provide the paved shoulder and graded shoulder cross slopes.
5. Provide the limiting stations where the typical section is applicable.
6. Provide typical grading details around the noise barrier in cut sections and fill sections. Include earth berm dimensions and cross slopes, distance from the noise barrier to the ditch centerlines, ditch dimensions, foreslope and backslope rates, and erosion control or seeding details.
7. Provide typical grading details around the noise barrier in a backslope location, including typical drainage and backfill details, and erosion control or seeding details.

#### C. General Notes

Provide general notes, not included in the standard bridge drawings or elsewhere in the project plans, that are necessary to complete the project plans and properly construct the noise barrier. For wall types other than precast concrete, include the approved supplier contact information provided in Figure 801-1 and Figure 801-2.

#### D. Noise Barrier Subsummary

Provide a noise barrier subsummary as described in Section 1307 of the ODOT Location and Design Manual, Volume 3, which includes all quantities required to construct the noise barriers that are not summarized elsewhere in the project plans.

#### E. Plan and Profile Sheets

Plan and profile sheets should conform to Section 1309 of the ODOT Location and Design Manual, Volume 3, and should detail the horizontal and vertical alignments of the noise barrier as follows:

1. In addition to the requirements of the L&D Vol. 3, include the following information in the plan view (using a 1"=20' horizontal scale):
  - a. All horizontal alignment data for the noise barrier.

Provide the noise barrier stationing at the begin point, end point and all intermediate deflection points of the barrier alignment; the bearing direction for all noise barrier segments; the deflection angle at all deflection points.
  - b. Graphically accurate representation of the panel segments and post locations including alignment centerline. In order to avoid congestion, post and panel labels should not be shown.

- c. All existing and proposed utilities, boundary lines, drainage facilities and other roadway incidentals (e.g. signs, fences, etc.) located within the construction limits of the noise barrier.
  - d. All soil boring locations and designations.
  - e. All proposed roadway, erosion control and drainage items and features to be constructed as part of the noise barrier installation.
  - f. The locations of all existing and proposed reference monuments. Locate all proposed monuments on the roadway side of the noise barrier, and relocate any existing monument as necessary to place it on the roadway side of the barrier. (Provide a pay item to relocate every existing Reference Monument located on the outside of proposed noise walls.)
  - g. Proposed construction limits encompassing the area that will be disturbed by the noise barrier construction.
2. In addition to the requirements of the L&D Vol. 3, include the following information in the profile view (using a 1"=5' vertical scale and a 1"=20' horizontal scale with vertical gridlines at 10-ft increments, horizontal gridlines at 25-ft increments and no grid subdivisions):
- a. A profile of the existing ground line taken along the centerline of the proposed noise barrier, with elevations provided every 25-ft and at abrupt elevation changes.
  - b. All existing and proposed underground utilities and drainage facilities located within the construction limits of the noise barrier. Label the disposition of existing items.
  - c. The acoustic profile line and elevations determined from the preliminary data in the project noise analysis report.
  - d. The length of all panel spans.
  - e. Each panel number or designation.
  - f. A profile of the final ground line taken along the centerline of the proposed noise barrier with elevations provided every 25-ft and at abrupt elevation changes.
  - g. The top and bottom elevations of each noise barrier panel between adjacent posts.
  - h. The locations of noise barrier panels with special architectural surface treatments, form liners or icons that differ from the normal surface treatment for the project.
  - i. The locations of drilled shafts with a diameter greater than 30" or other special foundation types.
  - j. The approximate top of bedrock elevation at each soil boring location (where applicable).

#### F. Cross Sections

Provide cross sections along the centerline alignment of each noise barrier. The cross section shall conform to Section 1310 of the ODOT Location and Design Manual, Volume 3 and

include the following:

1. Earth berms or other special grading that is required to construct the noise barrier at the proper elevation.
2. Proposed ditches required to properly convey stormwater runoff around the noise barrier.
3. Profiles of proposed drainage facilities within the construction limits of the noise barrier (not including the noise barrier underdrains) that are not shown elsewhere in the project plans.

Cross sections may be omitted if the project does not require cut and/or fill to construct the noise barrier wall.

The noise barrier cross sections as described above may be shown on the roadway cross sections. If provided with the roadway sections, in addition to the roadway station, provide the noise barrier station at each cross-section. Also include cross-references in the noise barrier plan subset listing the location of the noise barrier cross sections in the overall plan set.

#### G. Noise Barrier Data Tables

Provide completed data tables for each noise barrier similar to those shown in the sample noise barrier plans.

#### H. Miscellaneous Noise Barrier Details

Provide details not provided in the standard drawings or elsewhere in the project plans. Examples include: special architectural surface treatments or other aesthetic details; special post or panel cap details; noise barrier transitions at bridges; special panel details to accommodate fire hose connections; etc.

Sample Noise Barrier Plans are available on the Office of Structural Engineering website.

### **803.3            ADDITIONAL DETAIL DESIGN SUBMISSION REQUIREMENTS**

In addition to the project plans, the following information should be provided during the Stage 2 Detail Design Submission:

- A. A copy of the Office of Environmental Services requirements for location and height of noise barrier walls.
- B. The District Production Administrator should be contacted for the approved noise barrier material types, suppliers, alternate bid requirements, and special features in accordance with the Department's Noise Wall Policy 417-001(P). A copy of the letter from the District Production Administrator stipulating the information in this paragraph should be part of the detailed design submission.

## **804 NOISE BARRIERS – APPROVAL OF WALL DESIGNS**

Individual manufacturers of noise barrier for material types other than precast concrete shall submit panel designs. If approved, those designs will be added to Figure 801-1 or 801-2. A modification to an approved wall design requires a resubmission to the Department for approval. The Department will not allow a modified design to be used on a construction project prior to its approval.

Environmental, structural and acoustic design for the walls shall meet the requirements of 805.1, 805.2 and 805.3 of this manual.

There are two types of noise barriers, reflective and absorptive. Noise barrier manufacturers interested in having their noise barrier wall approved should submit their proposed designs in accordance with 805.

## **805 NOISE BARRIER SUBMISSION REQUIREMENTS**

Manufacturers interested in having their noise barrier design approved shall submit an approval package to the Office of Environmental Services.

As a minimum, the submission package shall show compliance with the following design requirements:

- A. Environmental.....Section 805.1
- B. Structural.....Section 805.2
- C. Material.....Section 805.3

Submit three copies of the complete submission package to the Office of Environmental Services. Include the specific product trade name; company address; and name, phone number, and email address of a technical representative available to answer questions during the product review period. The Department will evaluate the submission and provide a written decision to the manufacturer no later than 60 days after the submission package is received.

### **805.1 ENVIRONMENTAL DESIGN REQUIREMENTS**

The Manufacturer's wall system shall show compliance with the Department's Aesthetic limitations provided in Section 802.2 and the following Acoustic requirements:

- A. Reflective noise barriers - Minimum TL (Transmission Loss) = 22 dBA
- B. Absorptive noise barriers:
  1. Minimum TL (Transmission Loss) = 22 dBA
  2. Minimum NRC (Noise Reduction Coefficient) = 0.70

All barrier material submitted shall be acoustically tested at an independent laboratory capable of performing the following tests:

- A. ASTM Standard Test Method for Sound Absorption and Sound Absorption Coefficients by Reverberation Room Method
- B. ASTM C423 and E795 (Latest editions)
- C. ASTM E90 and E413 (Latest editions)

### **805.2 STRUCTURAL DESIGN REQUIREMENTS**

As a minimum, the structural design of the Manufacturer's wall system shall conform to the 4<sup>th</sup> Edition of the "AASHTO LRFD Bridge Design Specifications", 2007; the AASHTO "Guide Specifications for Structural Design of Noise Barriers", 1989, including all interims; and this Manual.

The structural design submission shall also include:

- A. All design assumptions including:
  - 1. Physical and mechanical strengths of the component raw materials
  - 2. Physical and mechanical strengths of the final composite material
  - 3. Design method(s) and governing specifications used
  - 4. Design safety factors used including information on why the factors were chosen and how the material's environmental and loading durability affect those factors.
- B. Complete design calculations:
  - 1. Signed, sealed and dated by a registered professional engineer
  - 2. Using the following minimum wind pressures:
    - a. Ground mounted = 25 psf [1.2 kPa]
    - b. Structure mounted = 30 psf [1.4 kPa]
  - 3. Include all fabrication, shipping, handling and erection loads
- C. Fabrication and construction drawings showing wall details, dimensions, connections and any other information required to define the wall system.

### **805.3 MATERIAL DESIGN REQUIREMENTS**

The material design submission shall include:

- A. Test data documenting the physical and mechanical properties used for structural design.
- B. Test data documenting any long term decrease in physical and/or mechanical properties due to fatigue, creep, bond deterioration, etc.

- C. Test data documenting material durability to environmental variables including: UV, temperature, moisture, freeze-thaw, fire, salt, petroleum, pH, etc.
- D. Test data documenting material's performance to temperature changes expected under service conditions.
- E. Test data documenting durability of any applied coatings used to protect material from environmental deterioration.



Approved Reflective Barrier Suppliers		
Type	Suppliers	Drawings & Notes
Metal	<p>Empire International 36744 Constitution Drive Trinidad, Colorado 81082 Telephone: (719)846-2300 Fax: (719)846-7466</p>	<p>SB1 (3/11/92) Reflective Horizontal/Continuous Wall SB1 (3/11/92) Reflective Horizontal/One Span Shadowbox SB1 (3/11/92) Reflective Horizontal/Two Span Shadowbox SB2 (3/11/92) Reflective Vertical/Continuous Wall SB2 (3/11/92) Reflective Vertical/One Span Shadowbox SB2 (3/11/92) Reflective Vertical/Two Span Shadowbox</p>
Fiberglass	<p>CorTec Company 3401 S. Delaware Milwaukee, Wisconsin 53207 Telephone: (414)486-1876 or 1-800-879-4377 Fax: (740)636-3250</p>	<p>Crane CorTec Sound Barrier System Manual (4/1/90)</p>
Brick or Block Masonry	<p>Masonry Institute of Dayton 2077 Embury Park Road P.O. Box 14026 Dayton, Ohio 45414 Telephone: (937)278-7821 Fax: (937)599-3683</p> <p>Advanced Masonry Technology, Inc. 2786 Center Road P.O. Box 878 Brunswick, Ohio 44212 Telephone: (330)225-9496 Fax: (330)273-0046</p>	<p>Block Masonry Drawing Rev. (4/83) Notes Rev. (3/83) Brick Masonry Drawings Rev. (3/83)(2/85) Notes Rev. (12/91)</p> <p>Advanced Masonry Technology Brick Masonry Sound Barrier Panel Drawings: SBC1, SB1, SB2 &amp; SB3 Dated 8/6/02</p>
Fiberglass	<p>Carsonite International 10 Bob Gifford P.O. Box 98 Early Branch, South Carolina 29916 Telephone: (803)943-1172</p> <p>M.H. Corbin, Inc. 9021G Heritage Drive Plain City, Ohio 43064 Telephone: (614)873-8216 or 1-800-380-1718 Fax: (614)873-8095</p>	<p>#9106121-02-2 (3/5/92) Product Binder #30-02180-92 #SBSA1001, Sheets 1 thru 8, (10/22/97) #SBSA1002, Sheet 1, (10/22/97)</p> <p>FiberCor Composite Reflective Noise Barrier System sheets 1, 2 &amp; 3 dated 3/8/04</p>
Acrylic	<p>Durisol Inc./Cyro Industries 67 Frid St. Hamilton, Ontario Canada, L8P 4M3 Telephone: (905)521-8658 Email: Edwards@Durisol.com</p> <p>Faddis Concrete Products &amp; Plaskolite 3515 Kings Hwy Downingtown, Pennsylvania 19335 Telephone: 1-800-777-7973 or (610)269-4685 Fax: (215)873-8431 or (610)873-8431</p>	<p>Paraglas Soundstop Noise Barrier Sheet 20 mm Paraglas Soundstop Noise Barrier Sheet 25 mm Paraglas Soundstop GSCC Noise Barrier Sheet 20 mm (Structure Mounted Applications) Paraglas Soundstop GSCC Noise Barrier Sheet 25 mm (Structure Mounted Applications) Paraglas Soundstop Ready-Fit Panels</p> <p>Acoustaclear Noisebarrier with Optix NB Extruded Acrylic Drwg. No. GSF-B-2008-01 (18 sheets) dated 5/8/08</p>

Figure 801-1

Approved Absorptive Barrier Suppliers		
Type	Suppliers	Drawings & Notes
Metal	<p>Empire International            36744 Constitution Drive            Trinidad, Colorado 81082            Telephone: (719)846-2300            Fax: (719)846-7466</p>	<p>88SSA-101 Empire Silent Screen (1 of 2)(6/6/88)            88SSA-102 Empire Silent Screen (2 of 2)(6/6/88)            88SSA-301 Empire Sight and Sound Wall (1 of 2)(6/6/88)            88SSA-302 Empire Sight and Sound Wall (2 of 2)(6/6/88)</p>
	<p>Industrial Acoustics Company, Inc.            1160 Commerce Ave.            Bronx, New York 10462            Telephone (718)931-8000 of (718)863-1138</p> <p>Faddis Concrete Products            3515 Kings Hwy.            Downingtown, Pennsylvania 19335            Telephone: 1-800-777-7973 or (610)269-4685            Fax: (215)873-8431 or (610)873-8431</p>	<p>Industrial Acoustics Metal Sound Absorptive            Dwg. C-9413-444-1 issue B dated 9/2/94</p> <p>Faddis – Metal Noise Barrier “ACOUSTAX” (AIR FORCE 1)            Sound Absorptive Noise Barrier Panels            Drawings 1 thru 8 dated 6/7/01</p>

Figure 801-2

Granular Soil Foundation Depth Table											
Barrier Height (H) [ft]	Post Spacing (PS) [ft]			Soil Properties	Foundation Depth [ft]						
	PS ≤ 8'	8' < PS ≤ 12'	12' < PS ≤ 16'		16' < PS ≤ 24'	N <sup>(3)</sup>	2-3	4-9	10-19	20-29	30-49
					φ <sup>(4)</sup>	25-32	27-35	30-38	32-40	34-43	36-44
					Level	8.0	8.0	6.5	6.0	6.0	6.0
					5:1	8.0	8.0	7.0	6.5	6.0	6.0
					4:1	8.5	8.5	7.0	7.0	6.0	6.0
					3:1	9.0	8.5	7.5	7.0	6.5	6.5
					2:1	10.0	9.5	8.0	7.5	7.0	6.5
					Level	9.5	9.5	8.0	7.5	7.5	6.5
					5:1	10.5	10.0	8.5	8.0	8.0	7.0
					4:1	11.0	10.5	9.0	8.5	8.0	7.5
					3:1	11.5	11.0	9.5	9.0	8.5	7.5
					2:1	12.5	12.0	10.0	9.5	9.0	8.0
					Level	11.5	11.0	9.5	9.0	8.0	8.0
					5:1	12.5	11.5	10.0	10.0	8.5	8.5
					4:1	13.0	12.0	10.5	10.5	9.0	8.5
					3:1	13.5	13.0	11.0	10.5	9.5	9.0
					2:1	14.5	14.5	12.0	11.5	10.0	9.5
					Level	15.5	14.0	12.0	11.0	10.5	10.5
					5:1	19.0	16.0	13.5	12.5	11.0	11.0
					4:1	20.5	17.5	14.0	13.0	12.0	11.5
					3:1	24.0	19.5	15.0	14.0	12.5	12.0
					2:1	*	30.0	19.0	16.0	14.0	13.0

Transverse Ground Slope

**Notes:**

1. The foundation depth is the required embedment into in-situ soil. Resistance provided by soil placed as new embankment should be ignored.
2. Barrier Height [H] is the distance from the top of the drilled shaft to the top of the higher barrier wall at the post rounded to the nearest ft.
3. N = Corrected SPT N-value (see BDM Section 802.1.2)
4. φ = Estimated friction angle based on N-value
5. \* = exceeds maximum drilled shaft length

**Figure 802.1.2-1**

Cohesive Soil Foundation Depth Table											
Barrier Height (H) [ft]	Post Spacing (PS) [ft]			Soil Properties	N <sup>(3)</sup>	Foundation Depth [ft]					
	PS ≤ 8'	8' < PS ≤ 12'	12' < PS ≤ 16'			16' < PS ≤ 24'	0-1	2-3	4-8	9-15	16-32
Barrier Height (H) [ft]	H ≤ 12'	H ≤ 10'	H ≤ 8'	H ≤ 6'	Transverse Ground Slope	Level	12.5	12.5	7.0	6.0	6.0
						5:1	13.5	13.5	7.5	6.0	6.0
						4:1	13.5	13.5	7.5	6.0	6.0
						3:1	14.0	14.0	8.0	6.0	6.0
	12' < H ≤ 16'	10' < H ≤ 14'	8' < H ≤ 12'	6' < H ≤ 10'		Level	14.5	15.0	8.0	6.0	6.0
						5:1	17.0	17.0	9.5	7.5	6.0
						4:1	18.5	18.5	10.0	8.0	6.0
						3:1	19.0	18.5	10.5	8.0	6.0
	16' < H ≤ 20'	14' < H ≤ 20'	12' < H ≤ 16'	10' < H ≤ 14'		Level	19.5	19.0	10.5	8.0	6.0
						5:1	20.0	20.0	11.0	8.5	6.0
						4:1	21.5	21.0	13.5	9.5	6.5
						3:1	23.0	23.0	14.5	10.0	7.0
			16' < H ≤ 20'	14' < H ≤ 20'		Level	23.5	23.0	14.5	10.0	7.0
						5:1	25.0	24.0	15.0	10.5	7.0
						4:1	25.5	24.5	16.0	11.0	7.0
						3:1	*	*	19.0	13.0	9.0
				5:1	*	*	20.5	14.0	9.0		
				4:1	*	*	21.0	14.5	9.0		
				3:1	*	*	22.0	15.0	9.5		
				2:1	*	*	24.0	15.0	10.0		

Notes:

1. The foundation depth is the required embedment into in-situ soil. Resistance provided by soil placed as new embankment should be ignored.
2. Barrier Height [H] is the distance from the top of the drilled shaft to the top of the higher barrier wall at the post rounded to the nearest ft.
3. N = Corrected SPT N-value (see BDM Section 802.1.2)
4. \* = exceeds maximum drilled shaft length

Figure 802.1.2-2